

## Going Green Ain't Easy; Chemical Firms Gauge Payback

**C**hemical companies say they are investing cautiously as consumer and regulatory demand increases for "green" products, or those that make only a minimal impact on the environment and human health. While many companies have green product R&D budgets and are launching new products, they say that they will only invest in environmentally friendly technologies when doing so makes good business sense.

The industry's work in green chemistry so far includes: developing new products, such as bioplastics and biofuels; implementing technologies to reduce pollution and waste for existing products; and replacing hazardous chemicals with nontoxic substitutes.

Dow Chemical is growing its green chemistry business, but says its renewable feedstocks program must compete on financial terms with existing processes or product attributes that customers will pay for. "There's no automatic payback for being green," says corporate v.p. and chief technology officer, William F. Banholzer. The company recently approved a new epichlorohydrin plant that uses a glycerin-based process "not because it's green, but because it's the cheapest." The company is also developing soy-based polyols for polyurethane foam. "Here, the cost advantage is neutral, but we can get some better product properties. That means sound financials, and improved functionality for customers," Banholzer says.

Dow says it dropped out of a joint venture with Cargill to produce polylactic acid (PLA), a biodegradable plastic produced from corn, because it was more expensive than existing materials and had no improved properties.

Cargill, however, reports success in that market, given the rising price of hydrocarbon-based resins. NatureWorks (Minnetonka, MN), Cargill's PLA business, has doubled its customer base, and more than tripled revenues since 2004. Market adoption of NatureWorks' PLA plastic is "growing rapidly" as retailers launch social responsibility programs, consumer brands look to differentiate themselves by using "natural" packaging, and as greenhouse gas becomes a significant issue, NatureWorks says. The company says that its corn-based resin, used to make beverage bottles and other clear plastic packaging, sells at prices that are on-par with polyethylene terephthalate (PET), the conventional resin that goes into plastic bottles. Cargill



'Natural' drinks: Cargill's PLA plastics are used in beverage bottles.



Starchy plastics: Firms develop plastics from agricultural feedstocks.

says it currently has name-plate capacity to produce 300 million lbs/year of PLA, and is investigating making a capital investment to meet growing demand.

Companies, including Archer Daniels Midland (ADM) and Metabolix (Cambridge, MA) are developing polyhydroxyalkanoate (PHA), a competing bio-based plastic. ADM and Metabolix formed a jv last year to build a 50,000-m.t./year facility at Clinton, IA to produce PHA (*CW*, March 22, p. 19). The plant will be built adjacent to ADM's wet corn mill in Clinton, and will use starch from the company's corn processing facility. The

companies say they expect construction of the plant to be completed in mid-2008. Metabolix says that the key advantage of its PHA product line is that the polymer architecture can be varied using its biotech production process to produce a wide range of properties.

Meanwhile, increased demand and high gas prices are attracting chemical companies to biofuels, another fast-growing market. These firms, which include pure-play chemical companies see an opportunity to make money by applying their existing technologies to biofuels, mainly biodiesel and fuel-blending chemicals. Earlier this year, DuPont and BP formed a 50-50 jv to develop, produce, and market butanol made from sugar beets for use as a gasoline blending component. The jv will produce the biobutanol at British Sugar's (Peterborough, U.K.) 30,000-m.t./year pilot plant under construction at Winsington, UK. The plant is expected to be operational in fourth-quarter 2007.

Dow Haltermann Custom Processing (DHCP), a Dow Chemical business, has been manufacturing biodiesel at a Houston plant for almost two years in an exclusive deal to supply biodiesel firm World Energy Alternatives (Chelsea, MA). DHCP has capacity to process 40,000 gal/year of vegetable oil.

Ineos confirmed plans earlier this month to build a world-scale biodiesel production facility at its Grangemouth, U.K. refining and petrochemical site. The company says that it expects the plant, which will have initial capacity of 500,000 tons/year, to be operational by 2008. Construction of the new plant is the company's first step toward meeting its goal of producing at least 2 million tons/year of biodiesel by 2012, with approximately 1.2 million tons/year by 2010, Ineos says. Ineos says it will make further investments to increase biodiesel production, potentially at the company's sites at Antwerp, Belgium; Lavera, France; and Wilhelmshaven, Germany or Cologne, Germany. Ineos says it will locate its biodiesel production "at the very heart of key demand centers." Locating these facilities at existing Ineos sites, will "provide us with cost-effective infrastructure, a ready-made and fully integrated customer base, in addition to access to some of Europe's very best transport networks," says Harry Deans, Ineos CEO.

Big oil companies are also getting into the biofuels market. BP and Chevron each have



announced biofuels investments this year. BP says it plans to invest \$500 million over the next 10 years to establish a bioscience energy R&D center to focus on developing transportation fuels from plants and organic matter (*CW*, June 21, p. 11). At the time of the announcement in June, BP CEO John Browne cited increasing demand for biofuels "to meet consumer desire for more environmentally responsible products, and to satisfy the requirements of governments for more energy to be home-grown."

Chevron recently formed a partnership with the Georgia Institute of Technology (Atlanta) to develop transportation fuels from biomass. Chevron says it will invest up to \$12 million in the alliance over the next five years. The alliance

will focus on: producing biofuels from cellulose; understanding the properties of biofuel feedstocks; and developing sorbents used to produce high-purity hydrogen.

As more biodiesel facilities come onstream, a challenge for producers will be excess glycerol, a by-product of biodiesel production, flooding the market. Chemical companies are developing technologies to use glycerol to produce valuable chemicals, however. Galen Suppes, a chemical engineering professor at the University of Missouri (Columbia) and chief science officer at technology firm Alternative Renewables (Columbia, MO), has developed a process for making propylene glycol (PG) from glycerol. Suppes says he is working with Senergy Chemicals (Gig Harbor, WA) to build a commercial-scale facility for his bio-based PG. The PG facility, to be built at an as yet undisclosed location in the southeast U.S., will initially produce 60 million lbs/year of PG, and rapidly ramp up to 100 million lbs/year, he says.

ADM, Cargill, and several other companies are developing bio-based PG processes. ADM has developed its own glycerol-to-PG process to be used at a polyols facility to be built at an as yet undisclosed location (*CW*, Nov. 30/Dec. 7, 2005, p. 23).

Cargill recently formed a new company to produce PG from glycerol. The company says that PG is the first of a platform of bio-based products that it plans to manufacture from glycerol. Cargill says it plans to build

facilities worldwide to produce PG from glycerol, with a target startup of mid-2008. Production will be based on a proprietary process, developed by Cargill and an unidentified third party. This proprietary process "increases production efficiency and lowers manufacturing costs with better yields and fewer by-products than other renewable and nonrenewable routes to propylene glycol production," Cargill says.

"Current PG capacities remain tight, and the fluctuation of propylene prices continues to batter the industry," says Jim Stoppert, senior director/industrial bioproducts at Cargill. These market dynamics create a ripe opportunity for a new, renewable, and stable product offering."

Several leading chemical firms have either formed separate business units or announced business

strategies to focus on "green" products and processes. Huntsman formed a business unit in April to help the company ramp up its green-chemistry initiatives (*CW*, April 26, p. 4). "Energy efficiency and green chemistry are not only better for the environment, they make sound business sense," says Don Stanutz, president/performance products at Huntsman. Huntsman says its green products include: propylene carbonate-based solvents; carbonates that reduce volatile organic compounds in paints; wood preservatives that replace a known human carcinogen; water-based paint primers; non-brominated flame retardants; and catalysts that eliminate emissions from insulating foams. "We are especially anxious to build our position in this burgeoning field through the use of bio-based feedstocks such as glycerin, natural alcohols, methylesters, carbohydrates, and sugars," Stanutz says.

DuPont has announced several green-chemistry initiatives over the past year. Most recently, DuPont identified plans to develop sustainable products and technologies, and reduce its environmental footprint, with a target of generating an additional \$6 billion/year in sales by 2015 (*CW*, Oct. 11/18, p. 11). DuPont's goals include: doubling R&D investment by 2015 in products with environmental benefits; generating

\$2 billion/year from products that reduce greenhouse gas emissions or improve energy efficiency; and doubling revenue to at least \$8 billion/year by 2015 from products based on renewable feedstocks.

**GOVERNMENT PUSH.** Legislation and government funding in the U.S. and Europe are also spurring the development of greener chemicals. Since 1996, EPA has recognized companies using green technologies in chemical design, manufacture, and use with the Presidential Green Chemistry Award. Codexis, Merck & Co., and the University of Missouri (Columbia) were among the winners of this year's awards (*CW*, June 28, p. 4). Codexis was recognized for developing a new route to a hydroxynitrile, an intermediate used in the production of atorvastatin, which uses "readily available feedstocks and two particularly clean biocatalytic reactions under neutral conditions." Merck received the award for developing a three-step process for the production of sitagliptin, the active ingredient of Januvia, a treatment for type 2 diabetes. The new process reduces waste production by 220-lbs/year of product, and increases overall yield by 50%.

On the legislative front, the European Union (EU) is driving the adoption of greener chemical processes via its Registration, Evaluation, and Authorisation of Chemicals (Reach) legislation. Reach is due to be introduced in early 2007. It is set to be the largest piece of environmental legislation to hit the chemical industry in over 20 years, requiring the registration of more than 30,000 chemicals, and authorization of about 1,000 potentially hazardous chemicals, some of which could be banned in certain applications, depending on how the legislation is finalized in the coming months.

In the U.S., the House recently passed the Green Chemistry Research and Development Act, introduced by Representative Phil Gingrey (R., GA) and Jim Marshall (D., GA) (*CW*, Oct. 4, p. 53). The bill would "strengthen federal efforts to find benign alternatives to today's chemical products," Gingrey says. "Several major chemical companies have seen great success using green chemistry, yet until now, the federal government has been slow to invest in this promising area," he says.

—MICHELLE BRYNER with ALEX SCOTT



Home-grown fuel: Turning waste cellulose into biofuels.

Chemical firms  
are forming  
'green'  
business units  
and strategies.

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